TEXTRON

Textron Inc.
1101 Pennsylvania Avenue, NW
Suite 400
Washington, DC 20004

Tel: (202) 637-3800
Fax: (202) 637-3861
www.textron.com

October 5, 2009

Ms. Marlene S. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: ET Docket No. 08-59

Dear Ms. Dortch:

Textron hereby submits its report entitled, "S Band Noise Floor Measurements and Signal Survey" concerning issues presented in the above-referenced proceeding.

The report documents measurements of the noise floor in the 2360 – 2395 MHz band. These measurements were taken at Cessna Aircraft Company facilities located at Mid-Continent Airport in Wichita, Kansas.

Please feel free to contact me should you have any questions regarding the report.

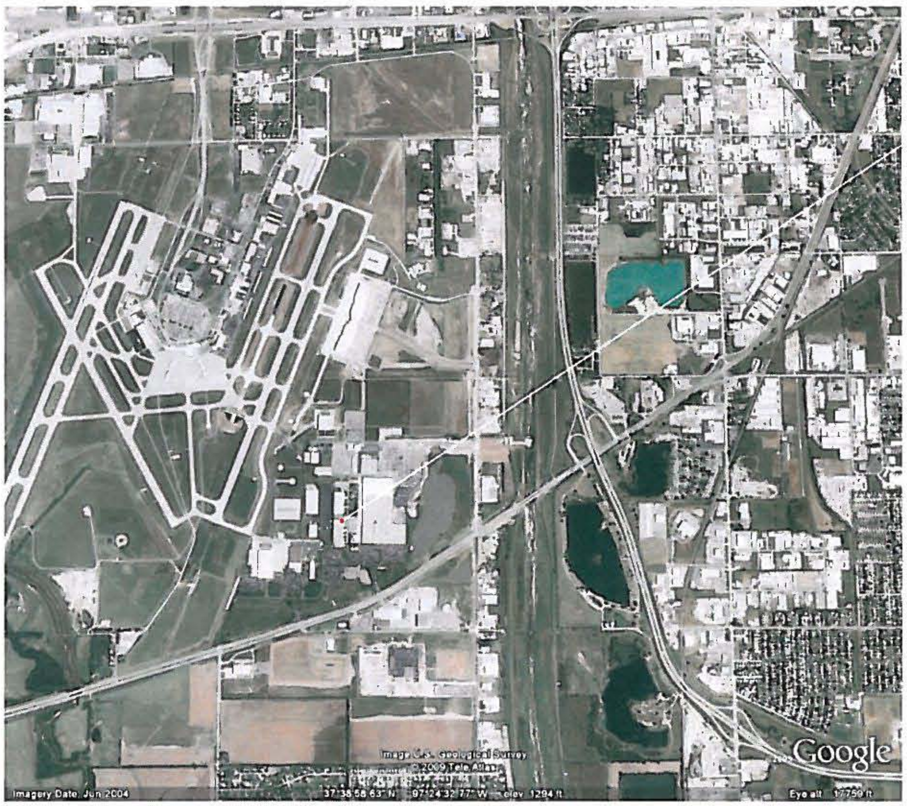
Sincerely,

Marc Ehudin

Marc L. Ehudin
Director, Government Affairs
Textron Inc.

S-band Noise Floor Measurements & Signal Survey

Cessna Aircraft Company, Wichita, Kansas
September 15, 2009



Dan Hankins
Senior Engineer
Spectrum Management Services
Cessna Aircraft Company

Table of Contents

Appendixes

List of Tables

List of Figures

1. Introduction

1.1 Summary

This report documents measurements of the noise floor in the 2360-2395 MHz band. The band 2360-2390 MHz is a restricted band allocated exclusively for Aeronautical Mobile Telemetry (AMT). 2390-2395 MHz is also allocated for amateur use. The measurements were taken at Cessna Aircraft Company facilities located at Mid-Continent Airport, Wichita, Kansas on Wednesday, July 15, 2009.

1.2 Measurement Goals

Proponents of a Medical Body Area Networks (MBANS) allocation in 2360-2390 MHz have made allegations to the effect that the band 2360-2390 MHz is subject to substantial out-of-band noise, chiefly from Part 15 devices in the 2.4 GHz band, as well as amateurs; and that the addition of in-band emissions from MBANS would be immaterial. Cessna Aircraft Company has undertaken to measure the S-band noise floor to provide quantitative data regarding this issue. Based on Cessna's measurements, it can be said that:

A. The noise floor in 2360-2390 MHz near an urban area like Wichita, Kansas is comparable to that of a rural area
B. Unlicensed devices in the 2400 MHz band have **not** polluted 2360-2390 MHz
C. Any Out of Band Emissions (OOBE) originating in the 2.4 GHz band are above 2390 MHz
D. AMT systems operating in 2360-2390 MHz are performance limited by noise, not interference

These conclusions are consistent with the long experience of AMT operators.

2. Noise Floor Measurement Equipment Description

2.1 Noise Floor Measuring Equipment

The measurement equipment consisted of a dual polarized horn antenna, AMT antenna filter, AMT antenna Low Noise Amplifier, shielded coaxial cables, spectrum analyzer, and a PC performing functions for automated spectrum analyzer control and data logging. The equipment in monitoring configuration is shown in Figure 1.

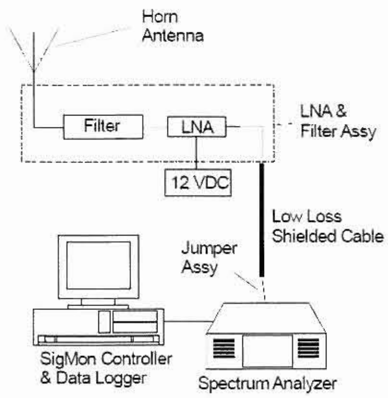


Figure 1: Equipment in Noise Floor Measuring Configuration

Noise Floor Measuring Equipment List

- Antenna
  - Q-par Angus WPHDP0.9-18 Ultra-Wideband Dual Polarization Horn, 0.9-18 GHz, 5.2 dBi gain and ~ 90 degree half power beamwidth at 2375 MHz. SN 6241.
- Spectrum Analyzer
  - Agilent N9020A MXA, 20 Hz – 26.5 GHz, SN MY48010838
- RF Switch Assembly
  - SAT Corporation S-4000-SW-6X26G Ethernet Controlled Switch, 6 input X 1 output, max recommended frequency = 26 GHz
- Filter
  - Micro-tronics BPC10159, pass band 1435 – 2400 MHz, 0.5 dB insertion loss, SN-028
- Low Noise Amplifier (LNA)
  - Miteq, AMF-3F-014024-04-10P-GF, 1.4 – 2.4 GHz, 35-40 dB gain, Gain Flatness 0.5 dB max, 0.4 dB Noise Figure, SN 986783.
- System Controller Hardware, Software & Data Logger
  - Panasonic CF-29 Toughbook, 1.6 GHz Pentium M, 1 GB RAM, 75 GB Hard Drive
  - SigMon software by SAT Corporation, with integrated Microsoft SQL Server running on Windows XP Pro

The Spectrum Analyzer and PC acting as the system controller and data logger are mounted inside a large equipment rack with external keyboard and monitor on a front console. A switch connects the spectrum analyzer to one of six inputs by command of the controller. The PC, spectrum analyzer, and switch are connected via an isolated Local Area Network inside the cabinet. This system is used by Cessna Spectrum Management to continuously monitor signals received by antennas mounted on the roof of the building, and was borrowed and adapted to perform the S-band noise floor measurements. The rack with components is shown in Figure 2.

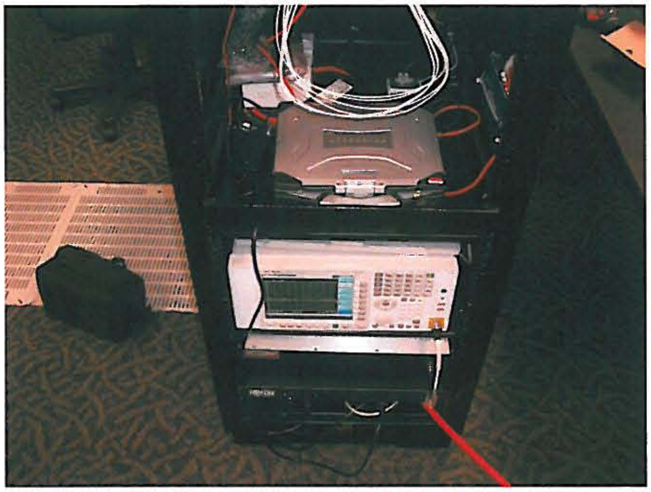


Figure 2: Signal Monitoring Rack, Rear View

The horn antenna was mounted on a tripod on the roof, with the Filter & LNA assembly connected to the A connector of the antenna. The antenna's A connector is vertical polarity. All measurements were taken using this connector as there was insufficient time to repeat the measurements using the horizontally polarized B connector. The LNA used in the Filter & LNA assembly is shown in Figure 3, and the antenna in Figure 4.

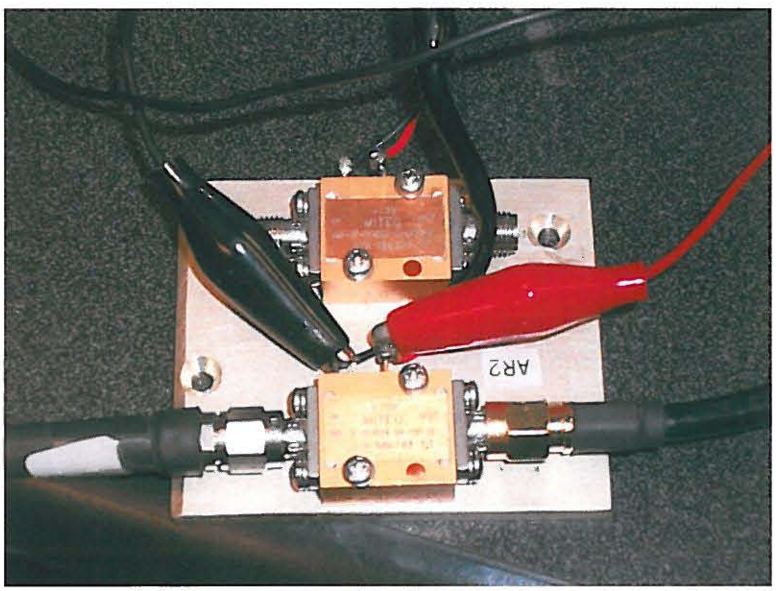


Figure 3: LNA in Filter & LNA Assy

Figure 4: Horn Antenna on Tripod

3. Equipment Gain & Noise Figure Measurements

3.1 Calibration Measurement Equipment

The equipment for measuring the gain of the cables, connectors, RF switch, filter and LNA consisted of an RF signal generator, 30 dB attenuator, power meter with power sensor and 50 ohm terminator. All cables and connectors comprising the Filter & LNA assembly, and other components of the measuring system were included in the gain and noise figure measurements, and are the same as in Figure 1.

<u>Measuring Equipment List</u>

- RF Signal Generator
  - Agilent N9310A RF Signal Generator, 9 kHz – 3 GHz, SN CN0115000514
- Power Meter
  - Agilent E4418B EPM Series Power Meter, SN MY45104581
- Power Sensor
  - Agilent E9300B E-Series Average Power Sensor, 10 MHz – 18 GHz
- Attenuator Assembly
  - Agilent 30 dB Attenuator Assembly, SN MY41495936
- Terminator
  - Weinschel Associates Model WA1426-3, 50 ohm, SN A491

3.2 Gain Measurements for the Filter & LNA Assembly

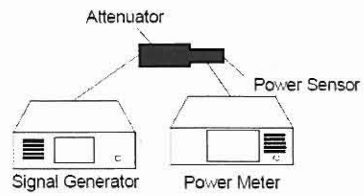


Figure 5: Gain Measurement Configuration for Zeroing the Power Meter

The signal generator, attenuator, power meter and power sensor were connected per Figure 5 above, with the power sensor connected to the attenuator. The gain was measured at 2360 MHz, 2375 MHz and 2390 MHz. These frequencies were selected to verify no changes in gain at the bottom, middle and top of the band for the gain, loss and system noise measurements in this section.

The signal generator remained on, and RF output was set to off while the Filter & LNA assembly was inserted between the attenuator and power sensor in the configuration shown in Figure 6 below. All components, cables and connectors comprising the Filter & LNA assembly were included in the measurements. The cables are spare Tensolite 510 prefabricated jumpers used in our EMP CMS03 telemetry antennas.

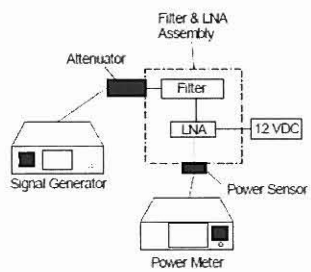


Figure 6: Gain Measurement Configuration for Filter & LNA Assembly

RF output was set to on, and gain measurements were taken at three frequencies. The data is shown in Table 1.

Table 1: Filter & LNA Assembly Gain Measurement Results

Frequency	Gain
2360 MHz	+33.9 dB
2375 MHz	+33.9 dB
2390 MHz	+33.9 dB

Additionally, RF power was increased to ascertain the dynamic range of the assembly. No drop in output gain was detected when input power to the assembly was less than -20 dBm. A test report for an LNA of the same model, provided by the manufacturer is in Appendix B of this document.

3.3 Loss Measurements for the Shielded Cable and Jumper Assemblies

The shielded cable assembly consists of two low loss shielded cables connected by an N-type feed-through "barrel" connector, and a short, flexible jumper assembly to connect the large coax to the switch and spectrum analyzer inside the mobile housing. The large cables are ECS 310801, permanently routed from the monitoring room to the roof, and LMR-600-LLPL cable to extend the roof cable to the monitoring rack. The loss of the shielded cable assembly, including connectors was measured by connecting it as shown in Figure 7.

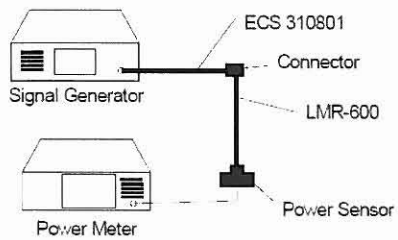


Figure 7: Loss Measurement Configuration for Shielded Cable Assembly

The signal generator was connected to the ECS cable on the roof and the power meter and sensor were connected to the LMR cable inside the telemetry room. Attenuation was measured at the bottom, top and middle of the 2360-2390 MHz band.

The jumper assembly was previously installed as a permanent fixture in Cessna's spectrum monitoring system, and serves to connect the large and comparatively inflexible shielded cable with N-type connectors to the delicate SMA switch connectors, and the switch output to the spectrum analyzer input. The 1 ft. jumpers provide strain relief protection for the equipment and are much easier to route inside the monitoring rack. The configuration for measuring the jumper assembly is shown in Figure 8, and measurement results for the shielded coax and jumper assembly are in Table 3.

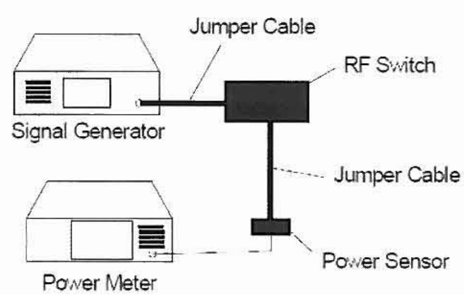


Figure 8: Loss Measurement Configuration for Jumper Assembly

Table 2: Shielded Coax & Jumper Assembly Loss Measurement Results.

Frequency MHz	Jumper Assy Loss (dB)	Shielded Cable Loss (dB)	Total Cable Loss (dB)
2360	1.2	7.6	8.8
2375	1.3	7.5	8.8
2390	1.3	7.9	9.2

3.4 System Noise Figure Measurement

The NASA UWB & Noise Floor Study of 2004 offers a commonly accepted method for measuring the Noise Figure of a high gain system. It is explained in the following manner:

> There are two primary sources of noise in the measuring system. The first is the noise power associated with all matter that cannot be filtered out. It is represented by the term kTB where:
>
> k = Boltzmann's Constant (1.38×10^{-23} Joules/°K)
> T = Temperature in Kelvin (293°K is standard)
> B = Bandwidth in Hz (1 Hz for our spectrum analyzer measurements)
>
> $kTB = (1.38 \times 10^{-23}$ Joules/°K)(293°K)(1 Hz) = 4.0434×10^{-21} Joules·Hz
>
> Converting this value to dBm/Hz is done as follows:
>
> $10\log_{10}(4.0434 \times 10^{-21}) = -203.9$ dBW/Hz = -173.9 dBm/Hz
>
> The value most commonly used by RF designers is -174 dBm/Hz.
>
> The second noise source is the system Noise Figure (NF_{SYS}) measured in dB.

NF_{SYS} can be derived by measuring the thermal noise power at the output of the measuring system while the input is terminated as in Figure 9 below.

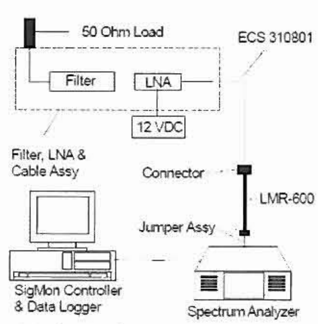


Figure 9: System Noise Figure Measurement Configuration

The system Noise Figure can then be calculated using the following equation:

$$NF_{SYS} = \text{Output Power} - \text{Total System Gain} - \text{Thermal Noise Power}$$
$$= P_{SA} - (G_{LNA} - L_{SYS}) - kTB$$

Where:

NF_{SYS} = Noise Figure of all system components from 50 ohm load to analyzer
P_{SA} = Power measured by the spectrum analyzer
G_{LNA} = Gain of the Filter & LNA assembly
L_{SYS} = Total losses of the shielded cables and jumper assembly
kTB = -174 dBm/Hz

The system was setup per Figure 9 using the same spectrum analyzer settings as for the noise floor measurements and four sweeps were taken at the bottom, middle and top of the 2360-2390 MHz band. The 50 ohm load is approximately equal to the natural noise floor. Each sweep takes just under 100 seconds to complete. Our choice of settings is explained further in section 5.1.

The four sweeps for each band were replayed with minimum hold, average and maximum hold enabled, and corresponding markers were placed at the center frequency for each band as in Figure 10 below.

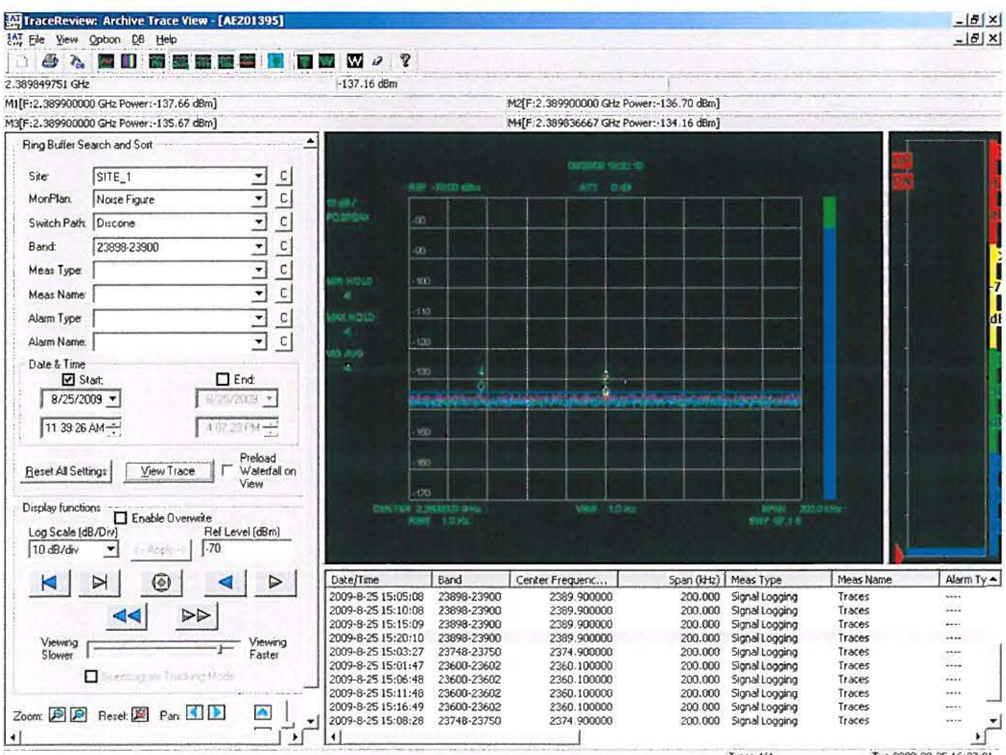


Figure 10: Min, Avg, Max Noise Figure Trace Review for 2390 MHz

The trace review in Figure 10 shows a 2 dB difference between the minimum and maximum values at the band center, and a 3.5 dB difference between the minimum value at center frequency and the maximum value in the 200 kHz band. This is consistent with the individual raw data traces.

As a check, the 50 ohm load was connected directly to the spectrum analyzer input per Figure 11 and six more sweeps were taken. All traces exhibited the same ~ 4 dB variation across each 200 kHz band. The spectrum analyzer settings are optimized for maximum detail and accuracy, minimizing the "smoothing" effect that results from larger bandwidth settings. One sweep for 2390 MHz, exported from SigMon is shown in Figure 12.

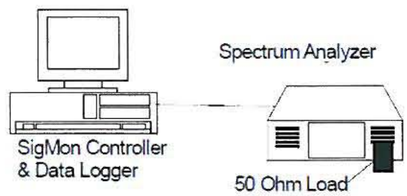


Figure 11: Terminator on Spectrum Analyzer Input

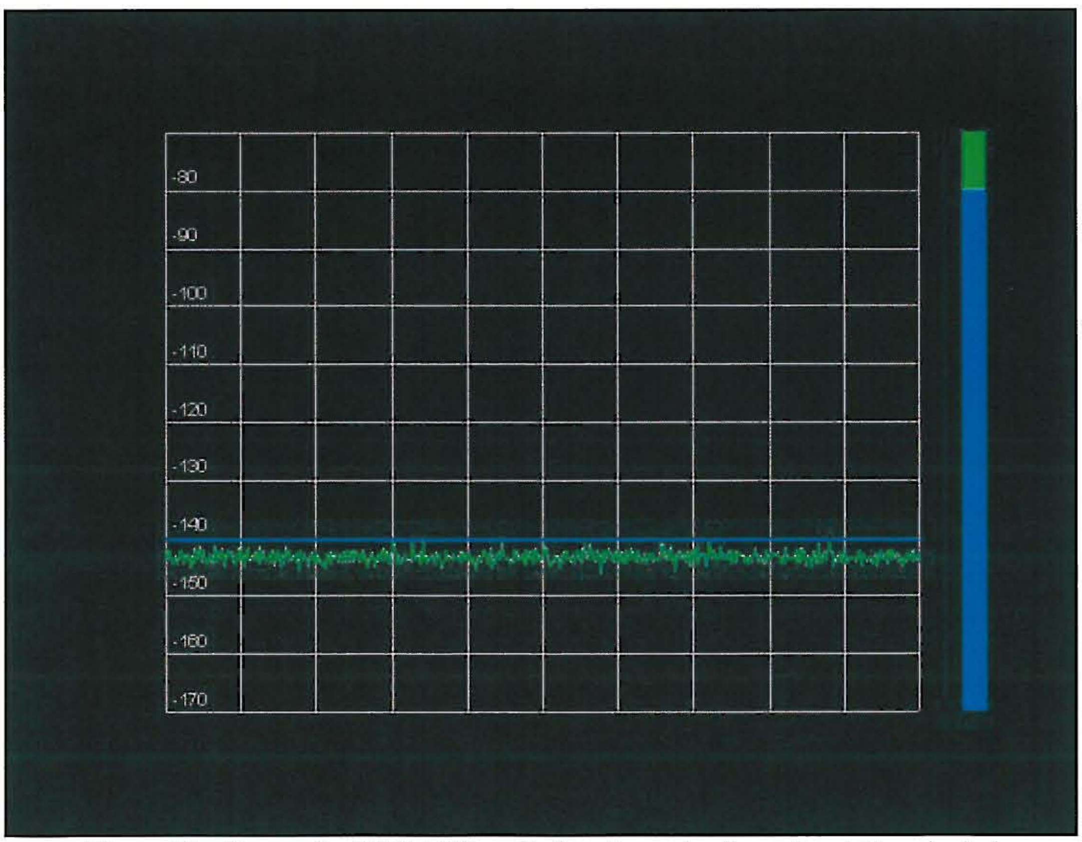


Figure 12: Sweep for 2390 MHz with Spectrum Analyzer Input Terminated

The equations for calibration in section 3, and for calculating the noise floor from the raw data in section 5, reveal that a lower system noise figure results in higher noise floor and signal or interference values calculated from the raw data. Calibration and correction values resulting in a higher noise floor and potential interference values favor the allegations by GE that the noise floor is polluted, and presents a worst-case scenario for AFTRCC. In the interest of presenting conservative, worst-case data, we will use the minimum hold center frequency value from the four sweeps (Figure 9 configuration) for each band to calculate the system noise floor. The results are given in Table 3.

Table 3: System Noise Figure Data

Frequency MHz	PSA Min Center (dBm/Hz)	Filter & LNA Assy Gain (dB)	Total Cable Loss (dB)	System Noise Figure (dB)
2360	-137.0	33.9	8.8	11.9
2375	-135.8	33.9	8.8	13.1
2390	-137.7	33.9	9.2	11.6

The values for bottom, top and middle of 2360-2390 MHz vary by much less than the ~ 4 dB variation across each of the 200 kHz sweeps documented when the spectrum analyzer input was terminated per Figures 11 and 12. This indicates the variation in cable loss and system noise figure as a function of frequency is significantly less than the variation of the power measured by the spectrum analyzer when using the 1 Hz resolution settings.

4. Measurement Site

4.1 Location

The roof of Cessna Building W2, Wichita Mid-Continent facilities was selected as the measuring site. This location is already in use as the primary location for signal monitoring by Cessna in Wichita, KS. The roof is 33 ft AGL, and with the antenna attached to a 4 ft. tripod it overlooks adjacent manufacturing buildings and has a good view of the downtown Wichita area. Cessna's fixed telemetry antennas are located on top of a 90 foot tower approximately 100 ft. southeast of the horn antenna.

4.2 Views from Measurement Site

Following are views taken from the measuring site at each of four cardinal directions.

Figure 13: View to North

Figure 14: View to East

Figure 15: View to South

Figure 16: View to West

4.3 Strong Signal Survey

A strong signal survey was performed on four azimuths to verify that signals of sufficient strength to affect LNA gain were not present in the pass band of the telemetry antenna filter used for the measurements. The antenna, cable assembly, spectrum analyzer and controller were connected as shown in Figure 17, without the Filter & LNA assembly.

Important Note: throughout this report, all measurements involving the Q-Par Angus horn antenna utilized only the vertically polarized "A" connector as there was insufficient time available to repeat the entire process for the horizontally polarized "B" connector.

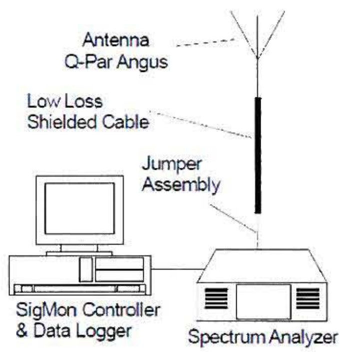


Figure 17: Strong Signal Survey Equipment Configuration

Since the half power beamwidth of the horn antenna is slightly more than 90 degrees, readings taken in 90 degree increments were deemed sufficient. The satellite view at 50 degrees magnetic is shown by the white line in Figure 18.

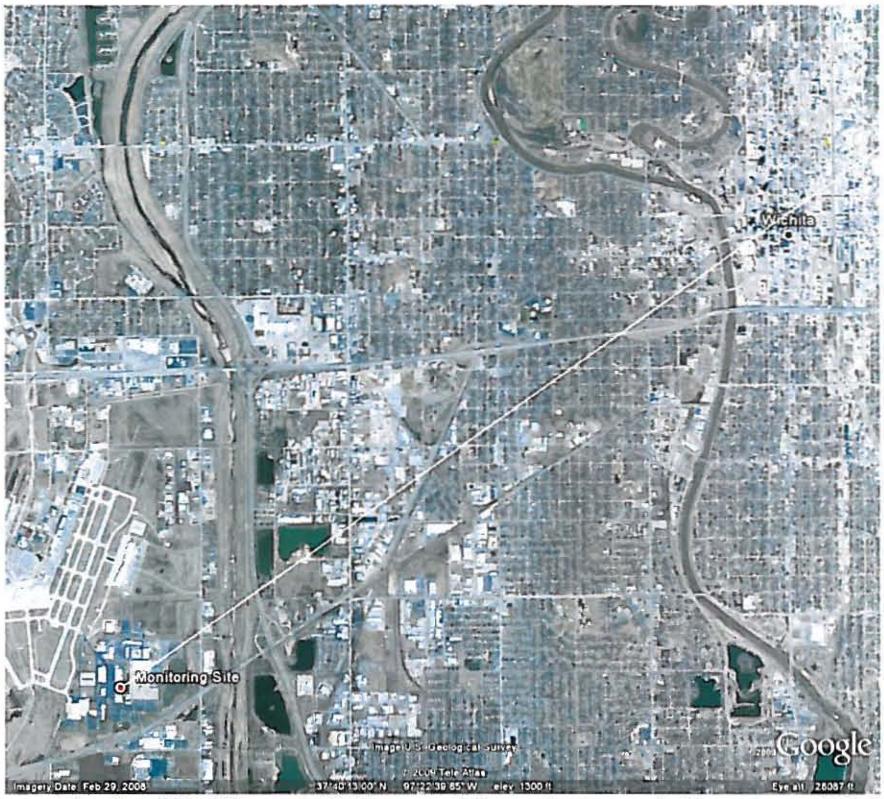


Figure 18: Satellite View at 50 Degrees Magnetic towards Downtown Wichita

The antenna was oriented to point towards the downtown high rise portion of Wichita at 50 degrees magnetic. Frequency sweeps from1350-2400 MHz, were performed at 50, 140, 230 and 320 degrees. The signals were well below the -20 dBm threshold that would cause the LNA to loose gain. The strongest signals were received at 50 degrees, and were in the 1.9 GHz PCS band. The results for all azimuths are in Table 4, and the sweep at 50 degrees magnetic is shown in Figure 19.

Table 4: Strong Signal Survey Results

Azimuth	Peak Power
50	-63 dBm
140	-68 dBm
230	-67 dBm
320	-64 dBm

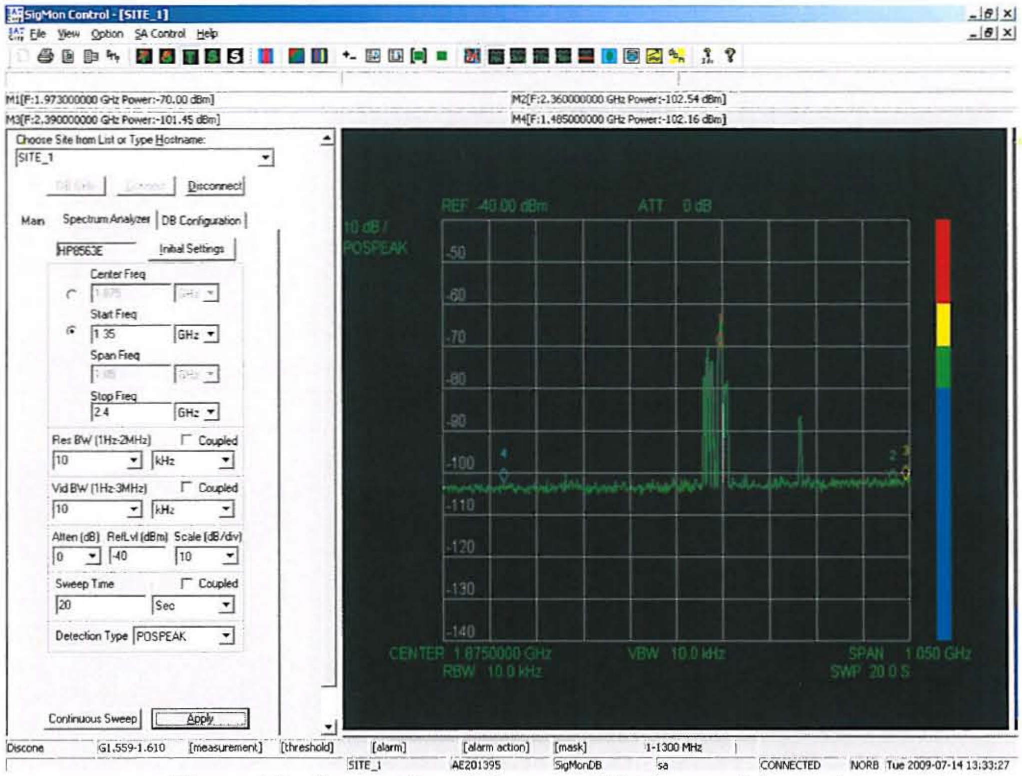


Figure 19: Strong Signal Sweep at 50 Degrees Magnetic

4.4 Measurement Azimuth

Due to the limited time available, we were confined to a single azimuth for the measurements. From the monitoring location the 90 degree half power beamwidth of the horn antenna covers a mixture of manufacturing, commercial, and dense residential areas when centered on the high rise buildings downtown. We believe 50 degrees magnetic to be the worst-case scenario, and the strong signal survey supports this decision. This azimuth also overlooks Cessna's largest manufacturing building, which dominates the view to the east in Figure 14. There are many 2.4 GHz RF devices in this building, including radio controlled cranes. Wi-Fi enabled laptops and access points operating in the 2.4 GHz band are common across the campus, including inside the monitoring building under the horn antenna.

5. Data Calibration

5.1 Spectrum Analyzer Settings

The spectrum analyzer was setup to use peak detection, no attenuation and resolution and video bandwidths of 1 Hz each. These settings can be compared to looking at the spectrum under a microscope, but slow compared to the much larger bandwidth settings used in some other noise floor measurements. The finer bandwidth settings can capture and display noise or interference of narrow bandwidths that could go unnoticed with larger bandwidth settings. To produce calibrated results, the spectrum was measured in 200 kHz spans with the sweep time set to 100 seconds. This is a time-consuming process, but necessary to capture and document interference having minimal bandwidth and/or amplitude. It also serves to document the noise floor at the input to the antenna in fine detail, as is evident in Figure 12 during the system noise figure check with the spectrum analyzer input terminated.

The reader may notice the figures showing the spectrum analyzer window of the SigMon Control Manager have the model set to HP8563E. The Agilent N9020A MXA spectrum analyzer is a new model. It was setup to emulate the remote command language of an HP8563E so it could be automatically controlled by the SigMon controller until a native driver was completed. This has no effect on the data.

5.2 Verification of Setup

The antenna, Filter & LNA assembly, cable assembly, spectrum analyzer, and SigMon controller and data logger were setup per Figure 20 below, which is the same as Figure 1.

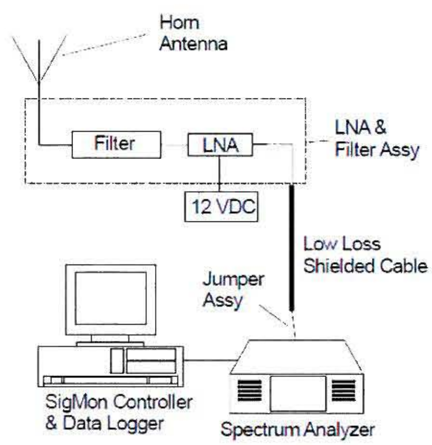


Figure 20: Noise Floor Measuring Equipment Configuration

Sweeps were performed using the spectrum analyzer settings in 5.1. During the sweep, the cable was disconnected from the spectrum analyzer and reconnected. This is shown in Figure 21. The 5 dB lower power measured when the cable was disconnected indicates the system measured the noise floor at the antenna input rather than the Displayed Average Noise Level of the spectrum analyzer.

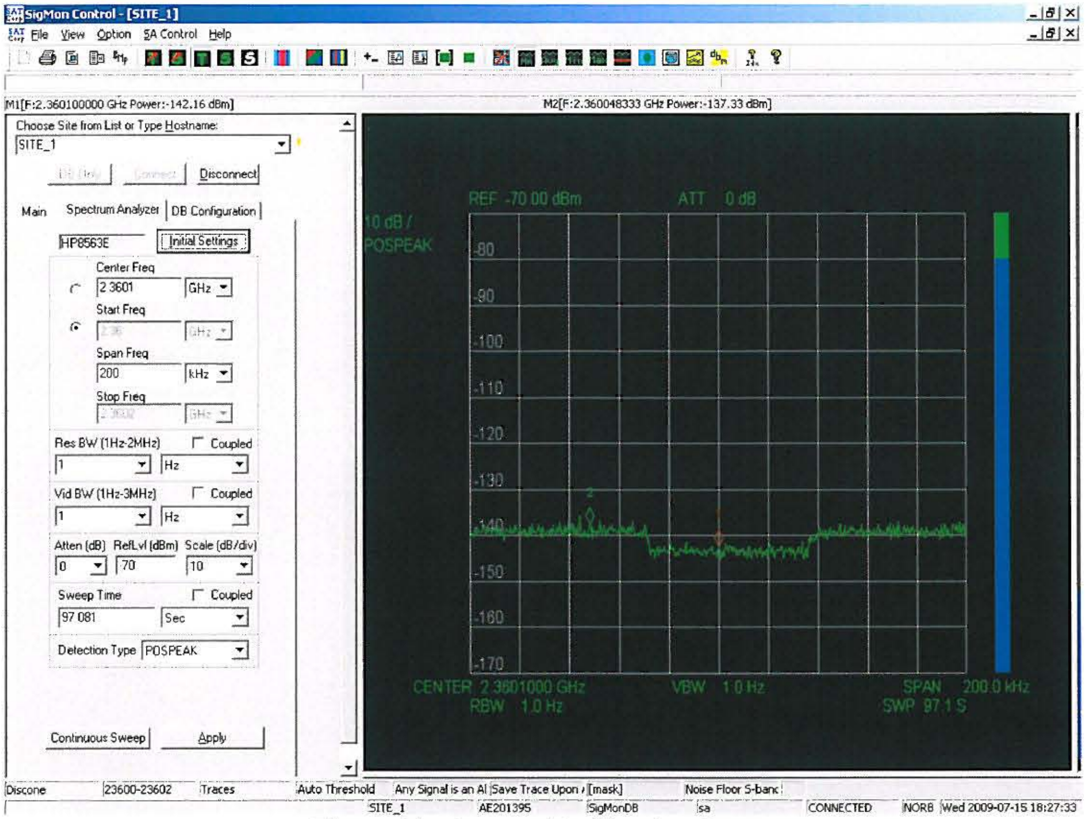


Figure 21: System Verification Sweep

Additionally, another sweep of the larger 1350-2400 MHz band was performed at 50 degrees magnetic to check against the 1.9 GHz signals shown in Figure 19. This sweep is shown in Figure 22, and it shows the signals now peak at -29 dBm. This is approximately 34 dB higher than the peak value previously obtained for this azimuth without the LNA. Even though the signals are dynamic, the results are consistent with the measured gain of the system.

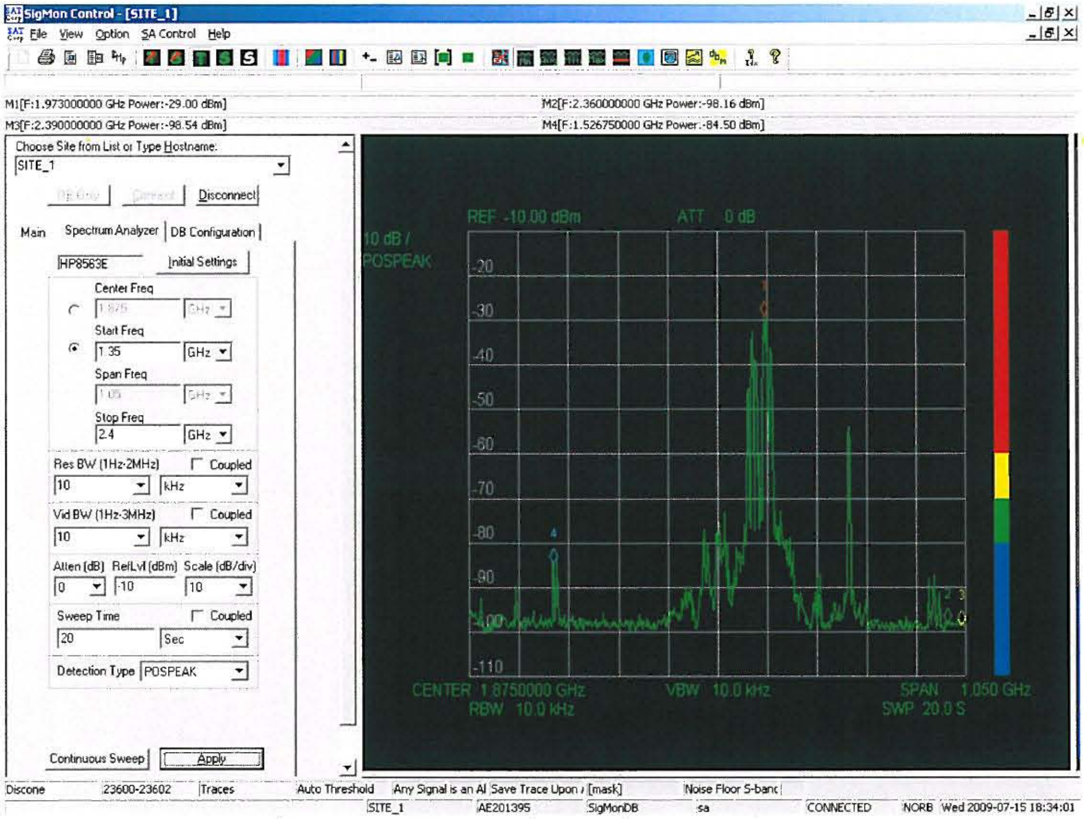


Figure 22: System Gain Check 1.9 GHz Sweep

5.3 Calculations

The NASA UWB & Noise Floor Study of 2004, section 2.2.1, paragraph 3 explains that:

> "The directional horn antennas amplify the man-made signals from sources near the horizon when they come under the main lobe of the antenna gain pattern. However, the natural noise will not be amplified if the noise background has a uniform noise temperature, and thus the measurement results by a directional antenna and ones by an omni-directional antenna are same in this case. Therefore, the measurement data will be presented without compensation for antenna gain to avoid a bias on measurements of the natural noise floor which can be introduced by the gain compensation process."

This report will follow the methodology used by NASA for calculating the noise floor, i.e., no antenna gain will be used in the noise floor calculations. When man made signals are present, as was the case with data taken while Learjet was conducting telemetry operations, the antenna gain of 5.2 dBi, should be factored into the data. The objectives of this report require the noise floor be measured within our desired precision. However, man-made signals need only be identified as present or absent within the 2360-2390 MHz band, and if present, determine whether they are coordinated telemetry signals that rightfully occupy the band, or other non-coordinated signals that could be considered as interference.

The noise floor measuring system results are described by the following equation:

$$P_{NFL} = P_{SA} + L_{Cable} + L_{FE} - G_{LNA} - NF_{SYS}$$

Where:

P_{NFL} = Power of the noise floor at the antenna input
P_{SA} = Power measured by the spectrum analyzer
L_{Cable} = Loss of the Cable
L_{FE} = Losses of the front end due to VSWR mismatch
G_{LNA} = Gain of the Filter & LNA assembly
NF_{SYS} = Noise Figure of the jumper assy, shielded cables, Filter & LNA assy

The mismatch loss of the antenna is taken from the antenna specifications, which give a VSWR less than 2:1. This equates to a 0.51 dB match loss. The spectrum analyzer data sheet specifies a maximum VSWR of 1.2:1, or 0.04 dB match loss. In keeping with our intent to present conservative data representing a worst-case scenario for AFTRCC, we will use the maximum measured cable attenuation value of 9.2 dB, and the minimum system noise figure value of 11.6 dB from section 3.

By inserting the values determined above and in previous sections, the equation yields the following results:

$$P_{NFL} = P_{SA} + 9.2 + 0.6 - 33.9 - 11.6 = P_{SA} - 35.7 \text{ dB @ } 2360 - 2390 \text{ MHz}$$

When a man made signal is present, the power at the antenna input should account for the antenna gain. This is done by subtracting the antenna gain from the equation above, and the equation for calculating the received strength of a man-made signal is given by:

$$P_{SIG} = P_{SA} - 35.7 \text{ dB} - G_{ANT} = P_{SA} - 40.9 \text{ dB @ } 2360\text{-}2390 \text{ MHz}$$

Where:

P_{SIG} = power of the signal
G_{ANT} = gain of the antenna = 5.2 dB

6. Measurement Band Considerations

6.1 Choice of Frequencies

Our desire to capture the data in fine detail made it necessary to break the 2360-2400 MHz band into sub-bands of 200 kHz each, and a sweep time of ~100 seconds was required for the spectrum analyzer to yield calibrated measurements for each 200 kHz sub-band. We had a time limitation of 2 days, during which we gathered equipment, assembled components, made calibration measurements, created an automated measuring plan, assembled the complete measurement system, executed the plan and gathered data. This would not have been attempted in the time available without automated system controlling and data logging, and could not have been completed without the cooperation and expert assistance of Cessna Aircraft Company's Flight Data Systems group.

We wanted to get representative data across the band, and were particularly interested in the band edges due to repeated allegations by GE Healthcare that 2360-2390 MHz is already polluted by OOBE from Part 15 devices operating in the 2.4 GHz band, and a proposal by the WCS Coalition to relax OOBE limits above 2360 MHz for WCS transmitters that would operate in the 2345-2360 MHz band. In order to accomplish the objectives in the available time, the automated plan was setup to sweep as follows:

a. 2359.8-2361.0 MHz: all 200 kHz bands in ascending order
b. 2361.2-2389.0 MHz: every other 200 kHz band in ascending order
c. 2389.0-2395.0 MHz: all 200 kHz bands in ascending order
d. 2395.0-2396.0 MHz: every other 200 kHz band in ascending order
e. 2396.5-2400.2 MHz: a 200 kHz band in every 500 kHz in ascending order
f. Repeat a through e as long as time permits

6.2 List of Center Frequencies

The center frequencies for the 200 kHz sub-bands are listed in Table 5 below.

Table 5: List of Center Frequencies for 200 kHz Sub-band Measurements

Center Frequency (MHz)	Center Frequency (MHz)	Center Frequency (MHz)	Center Frequency (MHz)
2359.9	2370.9	2382.9	2391.9
2360.1	2371.3	2383.3	2392.1
2360.3	2371.7	2383.7	2392.3
2360.5	2372.1	2384.1	2392.5
2360.7	2372.5	2384.5	2392.7
2360.9	2372.9	2384.9	2392.9
2361.3	2373.3	2385.3	2393.1
2361.7	2373.7	2385.7	2393.3
2362.1	2374.1	2386.1	2393.5
2362.5	2374.5	2386.5	2393.7
2362.9	2374.9	2386.9	2393.9
2363.3	2375.3	2387.3	2394.1
2363.7	2375.7	2387.7	2394.3
2364.1	2376.1	2388.1	2394.5
2364.5	2376.5	2388.5	2394.7
2364.9	2376.9	2388.9	2394.9
2365.3	2377.3	2389.1	2395.1

2365.7	2377.7	2389.3	2395.5
2366.1	2378.1	2389.5	2395.9
2366.5	2378.5	2389.7	2396.6
2366.9	2378.9	2389.9	2397.1
2367.3	2379.3	2390.1	2397.6
2367.7	2379.7	2390.3	2398.1
2368.1	2380.1	2390.5	2398.6
2368.5	2380.5	2390.7	2399.1
2368.9	2380.9	2390.9	2399.6
2369.3	2381.3	2391.1	2400.1
2369.7	2381.7	2391.3	
2370.1	2382.1	2391.5	
2370.5	2382.5	2391.7	

7. Spectrum Measurements

7.1 Execution of Measurement Plan

The first sweep was recorded at 8:32 am, and the last sweep at 6:18 pm on 15-July-2009. All traces are time stamped. Recording was continuous, without pause or manual intervention. The order of frequency sweeps followed the order specified in section 6.1. There are 117 center frequencies. The entire sequence of sweeps completed three times, and a total of 354 traces were recorded.

7.2 External Factors

Learjet, Inc. had telemetry flight operations in progress during the day, and their signals are recorded on many of the traces. Learjet has indicated that their telemetry activity included video and multiple data channels across the band. Their flight logs indicate they were conducting runway performance testing in close proximity to our monitoring site. Telemetry transmitters were reported to be active between 8:30 am until sometime after the last landing around 2:30 pm. The TM on times account for every man-made signal between 2360 and 2390 MHz that we recorded during the day.

Learjet telemetry signals are most clearly evident in section 7.3, Figure 23. Keep in mind that a single TM signal occupies much greater bandwidth than any single trace using a 200 kHz span. Due to the ~ 100 second sweep time, the aircraft location and attitude can change significantly during a single sweep, greatly altering the received signal strength over the course of a sweep. Despite this, for each 200 kHz sub-band there is at least one trace showing the noise floor when their transmitters were off, or the aircraft were so far away that their signals were not detectible by our equipment. However, a typical telemetry antenna would have 25 to 35 dB more gain than our horn antenna, and with the benefit of auto-tracking could easily make use of telemetry signals far beyond the range our measuring system could detect.

As noted earlier, there are many Wi-Fi enabled computers, access points and other Part 15 wireless devices operating in the 2.4 GHz band across the Cessna campus at the monitoring site. These provided a substantial number and variety of potential sources for spurious emissions and OOBE to prove or disprove the GE allegations concerning OOBE pollution from Part 15 devices operating above 2400 MHz.

7.3 Raw Data and Data Processing

SigMon records the raw data into a ring buffer. The ring buffer containing the data has been archived. The archived data was first filtered by band, and each individual trace was copied to an image file. Markers to specify frequency and power were placed as follows:

a. Marker 1: Center frequency and power in the band
b. Marker 2: Peak power and frequency in the band

These are shown for sweeps 1, 2 and 3 in the sub-band centered at 2364.9 MHz in Figures 23 through 25 below. The traces and marker values are what the spectrum analyzer received at its input, and are considered "raw" data. To determine the power level seen at the input to the antenna, the values for each trace must be adjusted per the calculations in section 5.3 according to whether or not a man-made signal is present.

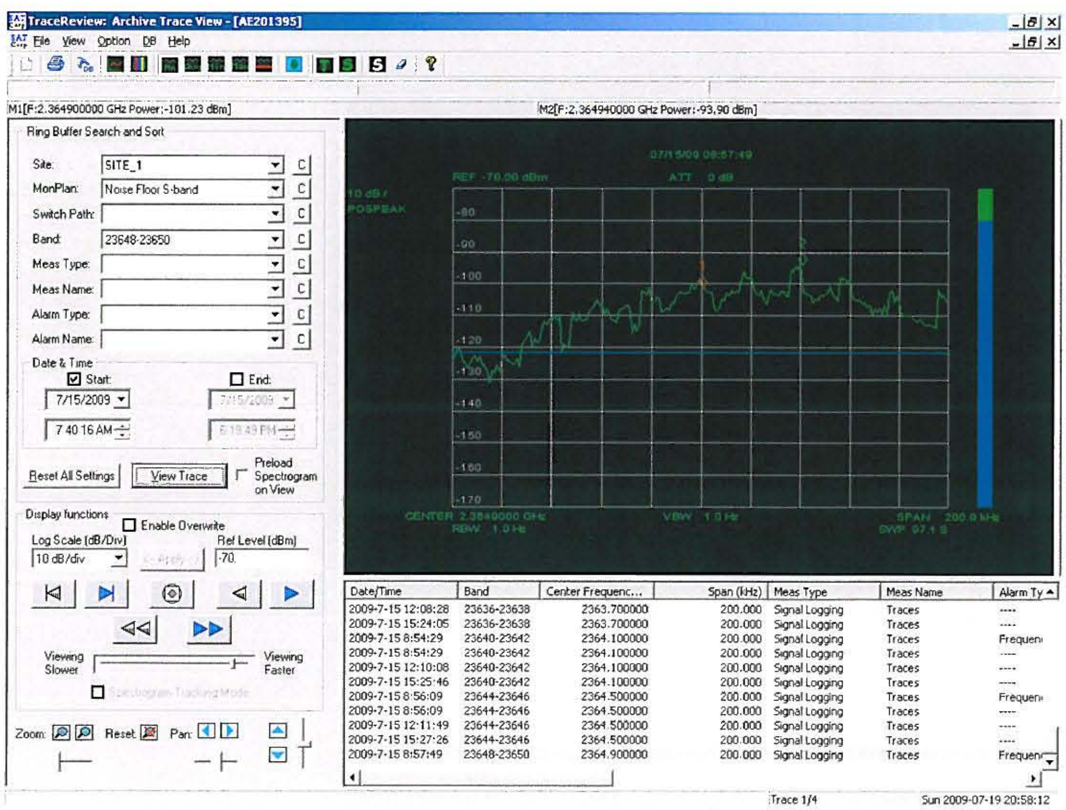


Figure 23: Trace 2364.8-2365.0 MHz, Sweep 1 – Learjet TM is present

A man-made signal is present. Using the value at the center frequency given by marker 1, the calculation for the power of the signal at the antenna input becomes:

$$P_{SIG} = P_{SA} - 40.9 = -101.2 - 40.9 = -142.1 \text{ dBm/Hz}$$

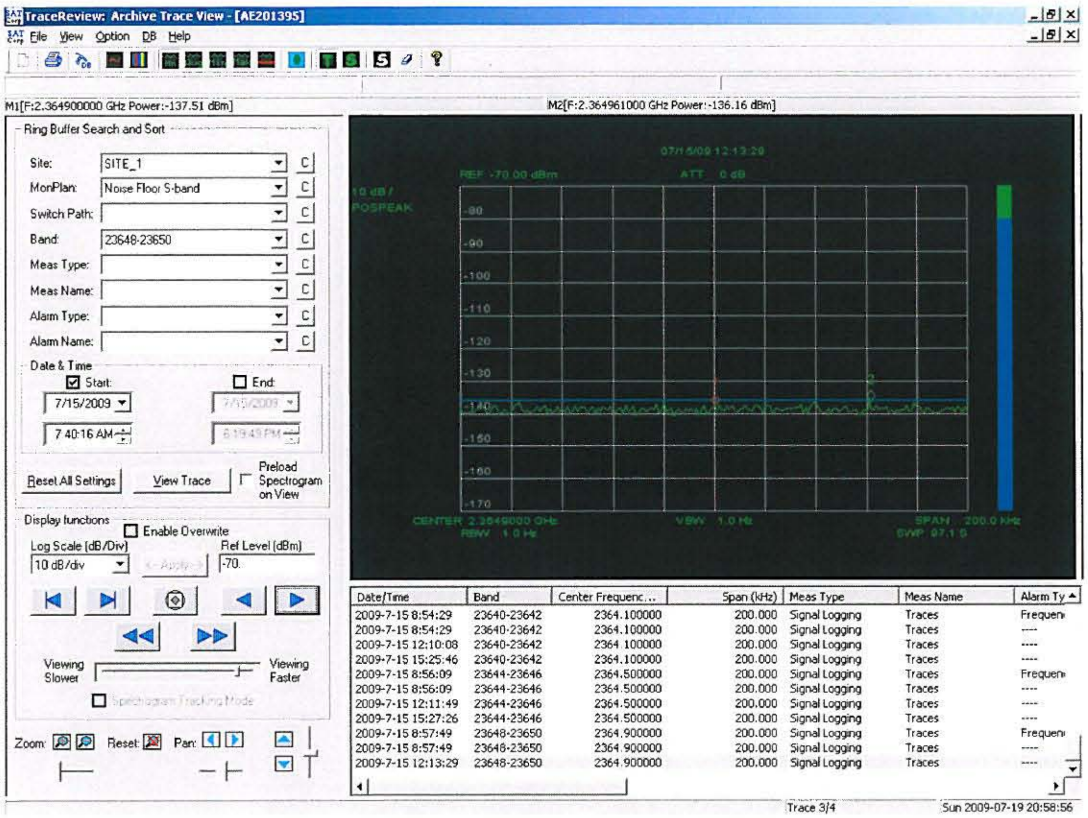


Figure 24: Trace 2364.8-2365.0 MHz, Sweep 2

No man-made signal is present, so we can calculate the power of the noise floor using the value at marker 1. The calculation for the power of the noise floor at the antenna input becomes:

$$P_{NFL} = -137.5 - 35.7 = -173.2 \text{ dBm/Hz}$$

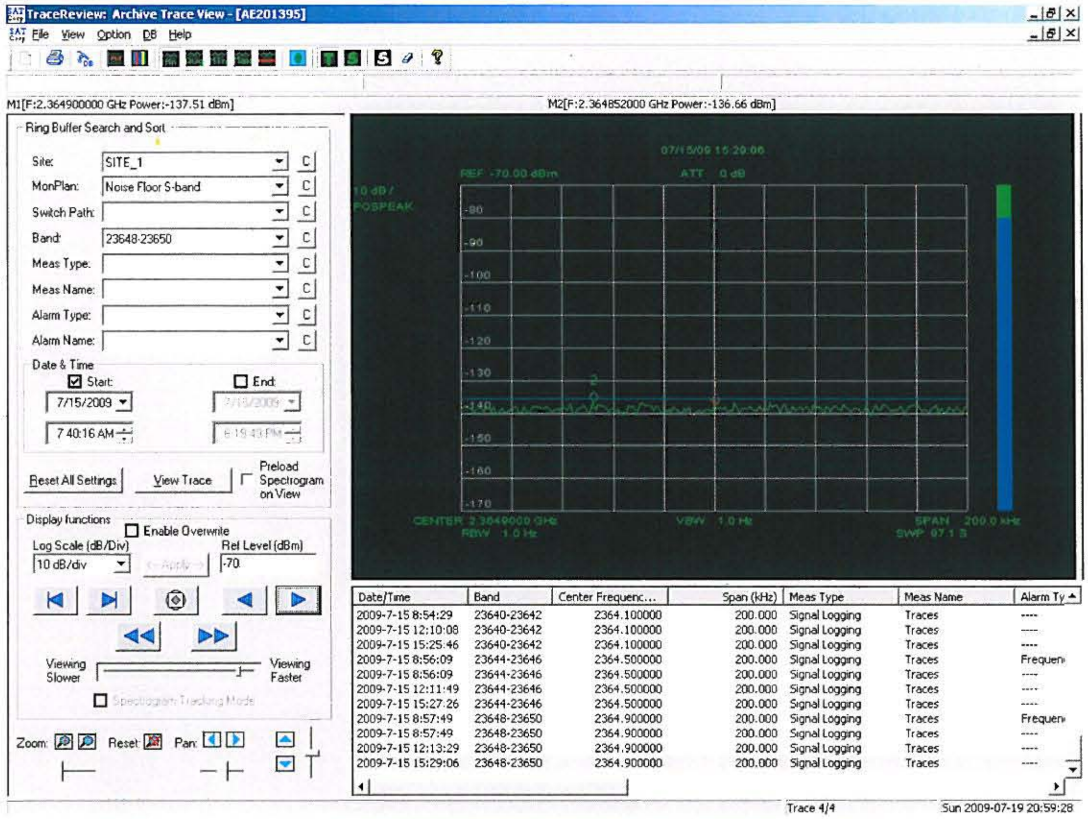


Figure 25: Trace 2364.8-2365.0 MHz, Sweep 3

No man-made signal is present. Using the value at marker 1, the calculation for the power of the noise floor at the antenna input becomes:

$$P_{NFL} = -137.5 - 35.7 = -173.2 \text{ dBm/Hz}$$

This value is identical to the value for sweep 2, but was taken over three hours later as verified by the time stamps. Note that there is a difference of 0.5 dB and 109 kHz for values given by marker 2 between the traces in Figures 24 and 25. Marker 2 locates the peak power for the trace.

We use the marker 1 values at the center frequency for each 200 kHz sub-band in the data we present in section 8. This eliminates any opportunity to bias our data by selecting data values from different locations within each sub-band to support our assertions. *All* of the marker 1 data has been graphed and is shown in section 8.

8. Conclusions

8.1 Data Tables & Graphs

A spreadsheet was created with rows for each center frequency, and a column for the power value given for markers 1 and 2 at each center frequency. The raw data for each sweep was entered into the appropriate fields as in Table 6.

Table 6: Raw Data Example

Raw Data								
	Individual Traces						Min/Max Center	
Center Frequency MHz	Sweep 1 Center	Sweep 1 Band Peak	Sweep 2 Center	Sweep 2 Band Peak	Sweep 3 Center	Sweep 3 Band Peak	Min Center	Max Center
2359.9	-135.8	-133.7	-138.3	-136.3	-139.2	-136.2	-139.2	-135.8
2360.1	-137.0	-128.2	-136.7	-136.2	-137.5	-136.3	-137.5	-133.7
2360.3	-135.0	-130.2	-138.5	-136.8	-138.0	-136.7	-138.5	-135.0

The correction factor of -35.7 dB was applied according to the equation for calculating the noise floor with no man-made signal present to all of the data and results displayed in a corresponding table as in Table 7.

Table 7: Corrected Data Example

Corrected Data								
	Individual Traces						Min/Max Center	
Center Frequency MHz	Sweep 1 Center	Sweep 1 Band Peak	Sweep 2 Center	Sweep 2 Band Peak	Sweep 3 Center	Sweep 3 Band Peak	Min Center	Max Center
2359.9	-171.5	-169.4	-174.0	-172.0	-174.9	-171.9	-174.9	-171.5
2360.1	-172.7	-163.9	-172.4	-171.9	-173.2	-172.0	-173.2	-169.4
2360.3	-170.7	-165.9	-174.2	-172.5	-173.7	-172.4	-174.2	-170.7

The corrected data was used to make the graphs used in the summary of results. Note that where man-made signals are present, the data does not account for antenna gain. We only determine whether or not a man-made signal is present on a trace, and if it is, we identify whether or not the man-made signal is a coordinated telemetry signal. Properly coordinated use is not interference from sources outside of the band.

8.2 Summary of Results

Our assertions - the purpose for the measurements and this report are restated in this section, and graphs of the data along with comments explaining how the data supports each assertion follow:

A. The noise floor in 2360-2390 MHz near an urban area like Wichita, Kansas is comparable to that of a rural area

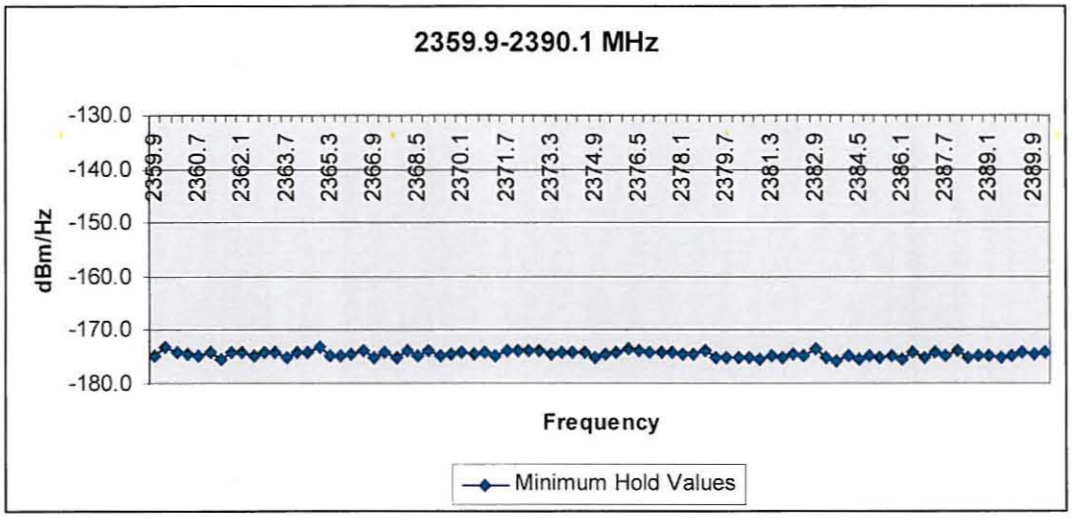


Figure 26: Graph of Minimum Hold Values for 2359.9-2390.1 MHz

Figure 26 above shows a graph of the minimum hold values for the discreet center frequency at each 200 kHz sub-band measured between 2359.9 MHz and 2390.1 MHz. The minimum values are close to the theoretical minimum when no man made signals are present, and all are within the ~ 4 dB variation documented in the system noise measurement check when the spectrum analyzer input was terminated. These results are not unlike the GPS L1 band results performed by the GPS Laboratory at Stanford in the NASA study mentioned earlier. This is what one expects in a rural environment where population and industry are sparse, but these measurements were taken in an urban environment. We attribute the fidelity of this band to the protection afforded it by the FCC Rules, and it is a testimony to their effectiveness in protecting AMT thus far.

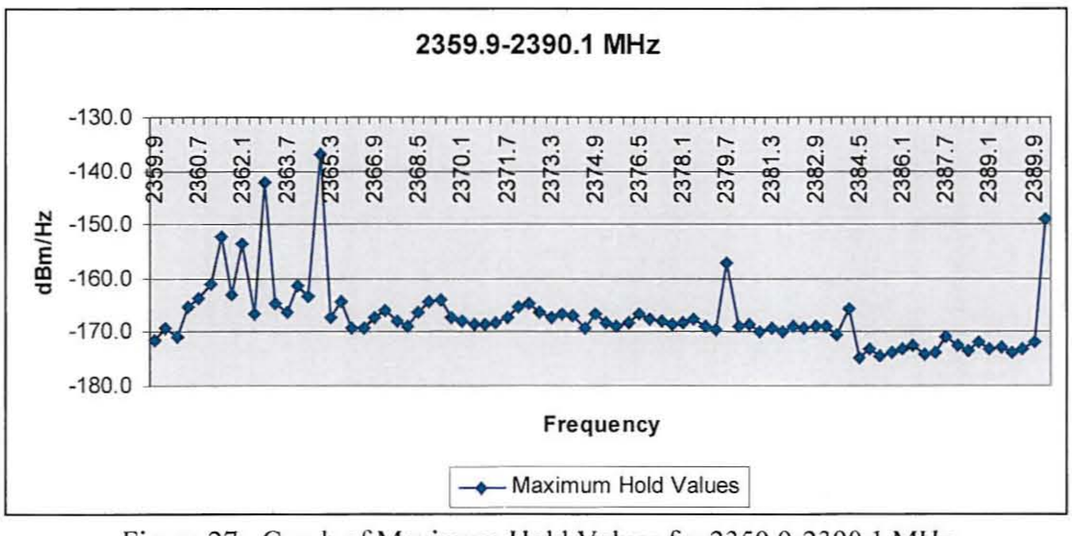


Figure 27: Graph of Maximum Hold Values for 2359.9-2390.1 MHz

Figure 27 shows the maximum hold values for the same discreet center frequencies graphed in Figure 26. All of the maximum values occurred when Learjet telemetry transmitters were reported to be on. Learjet reported having one video and multiple data channels active. The aircraft attitude and azimuth with respect to our horn antenna varied considerably during the hours in which data was taken, and we were not always measuring within the occupied bandwidth of an active telemetry channel. These factors cause large variations in the received signal strength measured by our system. Again, the Learjet telemetry antennas would have no trouble receiving the telemetry signals due to their far greater gain and automatic tracking of the aircraft. Also, their receivers would be tuned to the center frequencies of the telemetry channels during the mission.

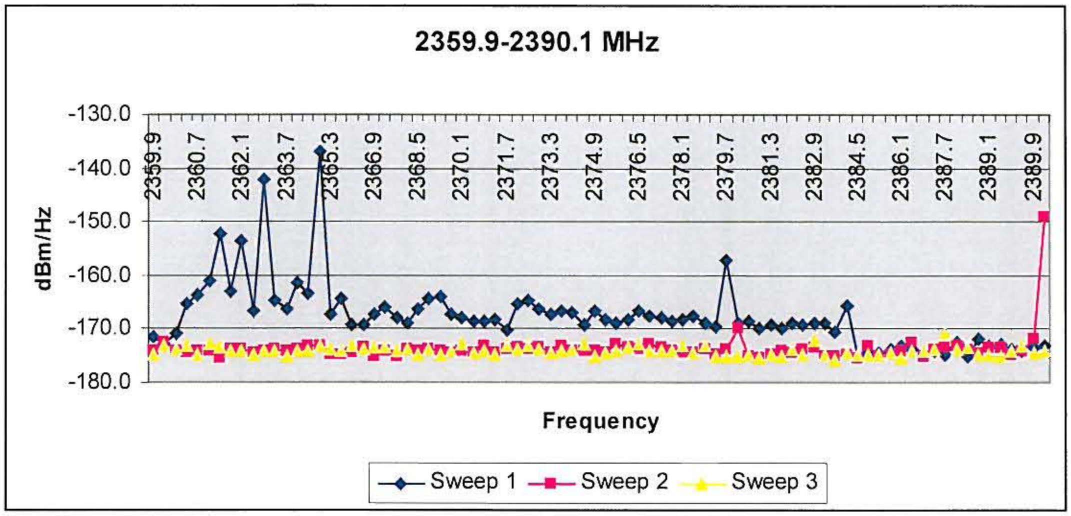


Figure 28: Graph of Individual Sweep Values for 2359.9-2390.1 MHz

Figure 28 shows the three consecutive sweeps on the same graph. From this you can judge the trend for when Learjet's telemetry transmitters were on and within range of our measuring system, while we were measuring a sub-band within or near to one of their telemetry channels.

B. Unlicensed devices in the 2400 MHz band have **not** polluted 2360-2390 MHz *and*

C. Any Out of Band Emissions (OOBE) originating in the 2.4 GHz band are contained above 2390 MHz

Besides the evidence of a pristine noise floor in 2360-2390 MHz when telemetry is absent, the graph in Figure 29 below shows the 200 kHz sub-bands centered from 2390.1-2400.1 MHz. The minimum value line shows the noise floor to be very clean.

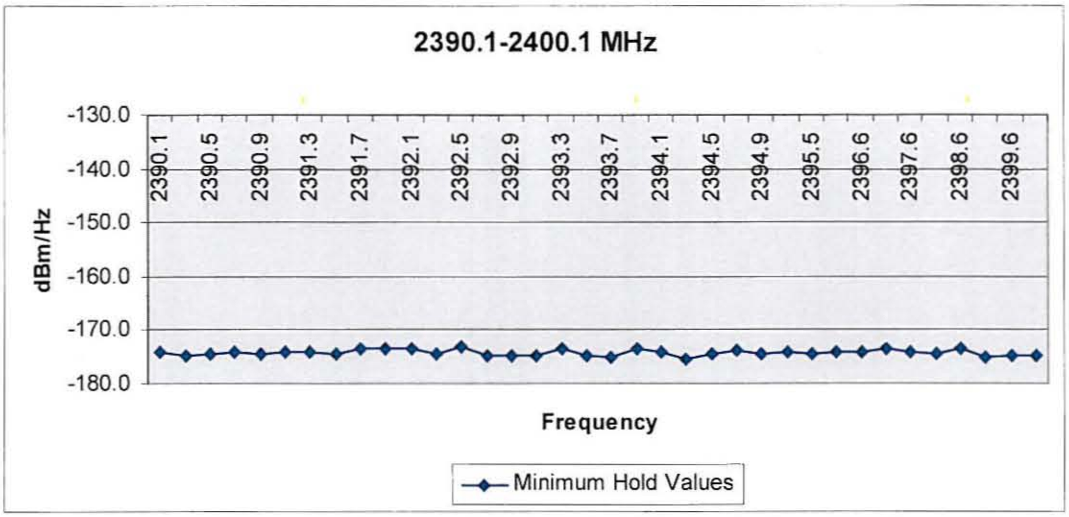


Figure 29: Graph of Minimum Hold Values for 2390.1-2400.1 MHz

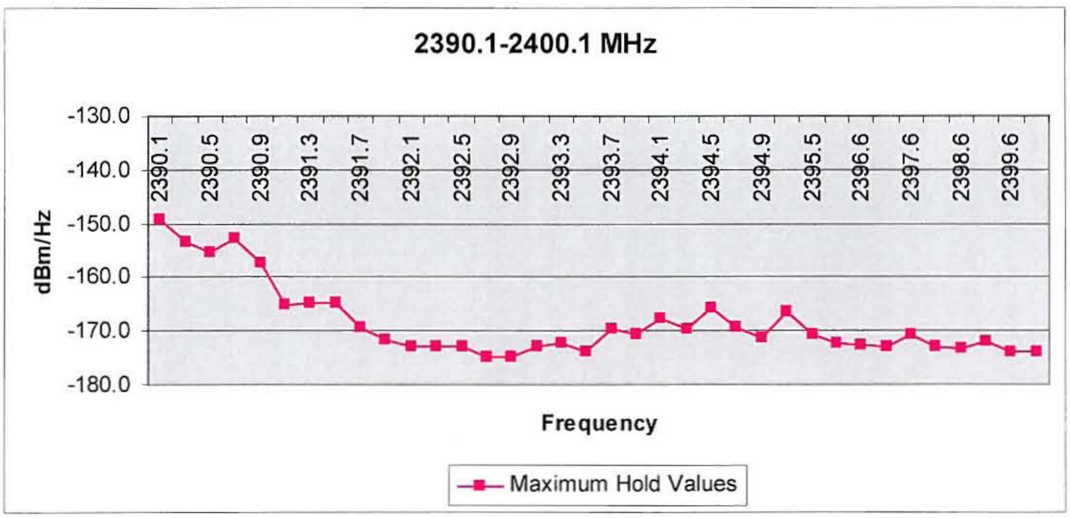


Figure 30: Graph of Maximum Hold Values for 2390.1-2400.1 MHz

The maximum values in Figure 30 indicating the presence of a man-made signal were recorded when Learjet telemetry transmitters were reported to be active. Figure 31 shows the individual sweeps for the band 2390-2400 MHz.

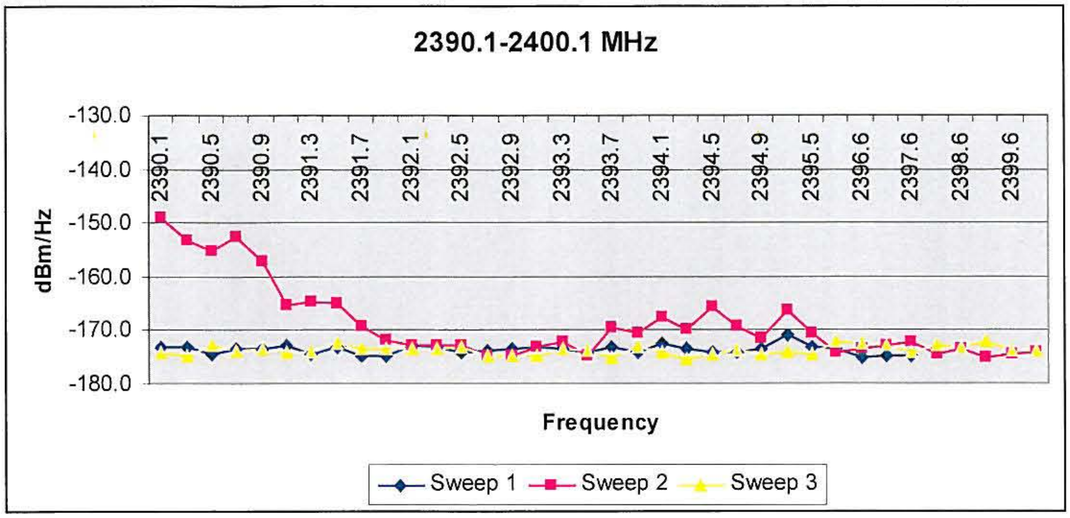


Figure 31: Graph of Individual Sweep Values for 2390.1-2400.1 MHz

D. AMT systems operating in 2360-2390 MHz are performance limited by noise, not interference

By providing data to validate assertions A, B and C, we have shown that interference from man made signals outside the band 2360-2390 MHz was not present within that band at our monitoring location in Wichita during the time that our measurements were taken. We also know from years of telemetry experience that pristine telemetry spectrum is the norm, not the exception. We made every reasonable effort to document our worst-case scenario. The location and time for performing the calibration measurements and collecting data were entirely dictated by matters of logistics as we were, and still are extremely confident in the veracity of our assertions.

Finally, we observe that while Learjet telemetry was active, there was considerable occupancy of the 2360-2390 MHz band for hours as seen from our location.

9. Declaration

9.1 Signed Statement

This report is true and correct to the best of my knowledge and belief.

Danny B. Hankins

Danny B. Hankins
01-October-2009

Appendix A

Spectrum Analyzer Specifications

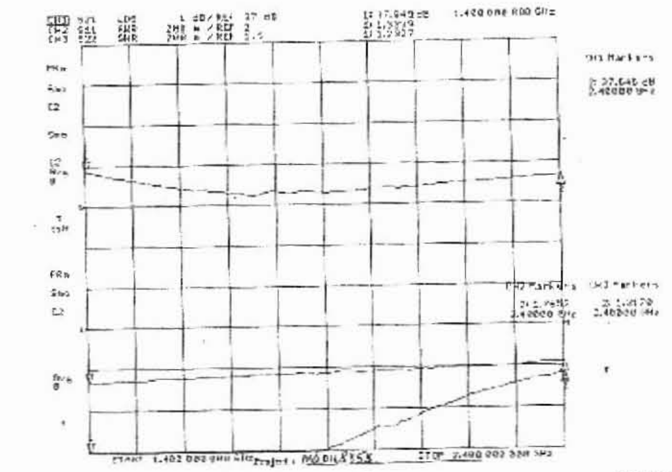
Complete specifications for the Agilent N9020A MXA are extensive, and available in a 21 page document on the Agilent web site. At the time of this writing, the link is: http://cp.literature.agilent.com/litweb/pdf/5989-4942EN.pdf. The table below contains specifications affecting our choice of spectrum analyzer and its settings.

Table A-1, Spectrum Analyzer Specifications

Parameter	Specification
RBW Accuracy	+/- 1% (+/- 0.044 dB) @ 1 Hz to 750 kHz
VBW Accuracy	+/- 6% nominal
VSWR	1.2:1 nominal @ 10 MHz to 3.6 GHz

Appendix B

Low Noise Amplifier Test Report



Project: MODIS/X55X

MITEQ INC.
100 Davids Drive
Hauppauge, New York 11788-2034
Tel. (631) 436-7400
FAX: (631) 436-7430

Int. Transfer: —
Customer P/N: —
Customer P.O.: —
Model Number: AMF 3F 014024-04-10P
Serial Number: 1447571

NOTE - This unit can safely handle a maximum input power of +10 dBm, CW.

SPECIFICATIONS

Frequency (GHz)	1.4 - 2.4 GHz
Gain (dB)	35-40 dB
Gain Flatness (dB)	± 0.5 dB max
Δ Gain vs. Temp (dB)	—
VSWR: Input / Output	2.0/1.5:1 max
Noise Figure	0.40 dB max
P_{out} @ 1 dB Comp (dBm)	+10 dBm min
Output IP3 (dBm)	—
Voltage (VDC)	+15 VDC
Current (mA)	150 mA nom.
Operating Temp (°C)	-40°C to +75°
Outline Drawing	12.1622

TEST DATA at +23°C

Frequency (GHz)	Noise figure (dB)	P_{out} @ 1 dB Comp (dBm)	
1.4	0.43	+16.9	
1.9	0.35	+17.8	
2.4	0.38	+16.7	

Measured Current: 123 mA

Maximum Input VSWR	Maximum Output VSWR
1.77:1	1.32:1

Tested By: [signature]

Date: 3/10/05

Appendix C

Antenna Test Report

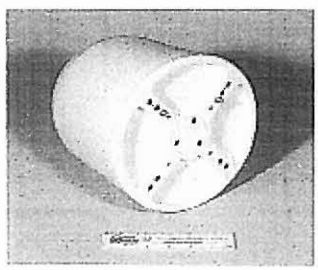
Q-par Angus Ltd

IDEAS ENGINEERED

Ultra-Wideband Dual Polar Horn

0.9 - 18 GHz

P/N:	WBHDP0.9-18S
S/N:	6241
Q-par ref:	D1572
Date:	27-Jun-08
Contents:	Summary
	Antenna Gain
	Beamwidth
	VSWR
	Isolation



Barons Cross Laboratories Leominster Herefordshire HR6 8RS UK
Tel +44 (0) 1568 612138 Fax +44 (0) 1568 616373
E-mail sales@q-par.com Web www.q-par.com

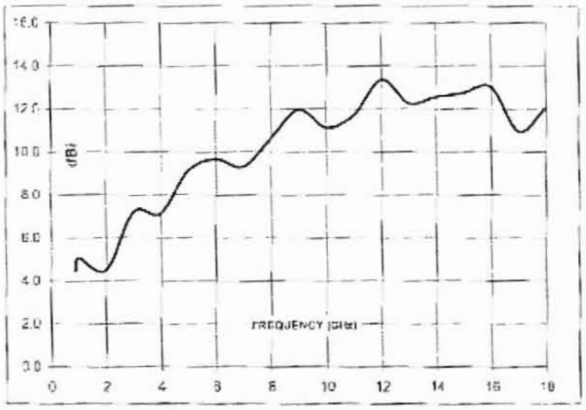
This report covers full electrical testing and has been produced for
Cessna Aircraft Company

Summary

Frequency	0.9 - 18 GHz
Connector type	2 x SMA Female
Typical VSWR	< 2:1
Gain	4.5 to 13.4 dBi
Isolation	typically >25 dB between connectors
Power handling	40 W
Weight	1.74 kg
Size- max.	215 mm diameter x 230 mm length
Mounting	4 holes M6, 90.8 PCD

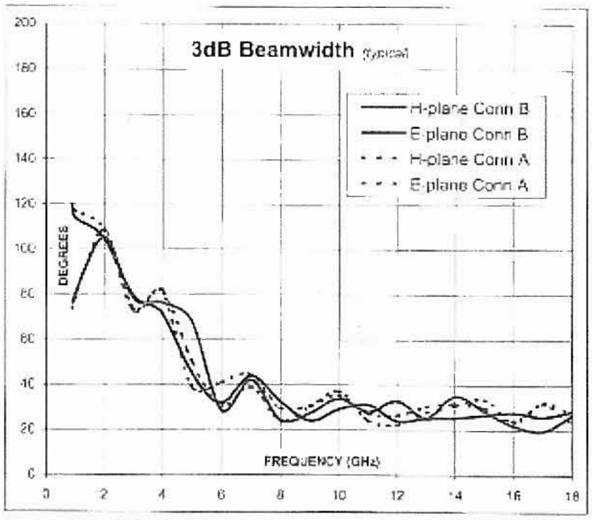
Typical Antenna Gain

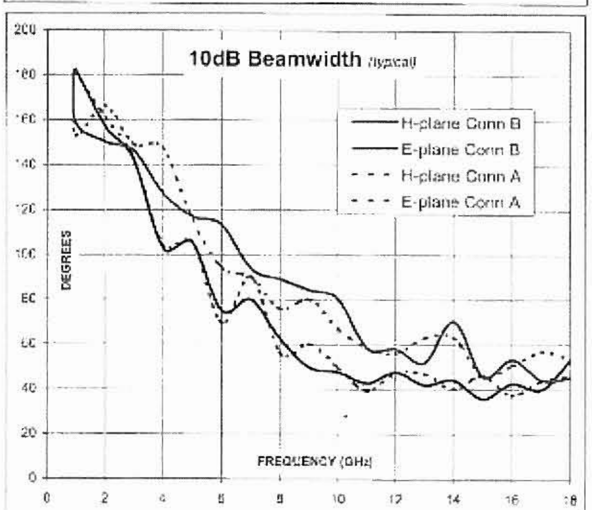
This is calculated by reference to standard gain horn antennas, and cross checked with reference to the antenna beamwidth, with an estimated error of +/- 0.8dB

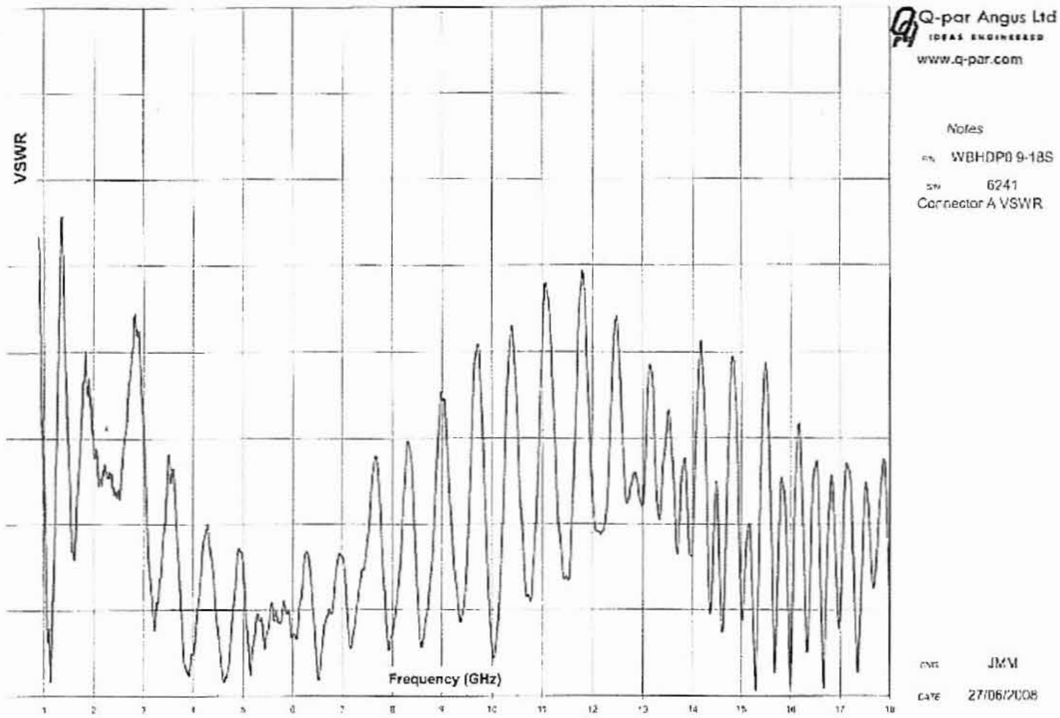


C-par Angus recommends the use of connector savers with this antenna

Frequency GHz	Gain dBi	Antenna Factor dB/m
1.0	5.1	25.2
5.0	9.1	35.1
9.0	12.0	37.4
15.0	12.7	41.0
18.0	12.1	43.3


3dB Beamwidth (typical)
H-plane Conn B
E-plane Conn B
H-plane Conn A
E-plane Conn A
DEGREES
FREQUENCY (GHz)


10dB Beamwidth (typical)
H-plane Conn B
E-plane Conn B
H-plane Conn A
E-plane Conn A
DEGREES
FREQUENCY (GHz)


Q-par Angus Ltd
IDEAS ENGINEERED
www.q-par.com
Notes
WBHDP0 9-18S
6241
Connector A VSWR
JMM
27/06/2008
VSWR
Frequency (GHz)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

Appendix D

Cable Data Sheets

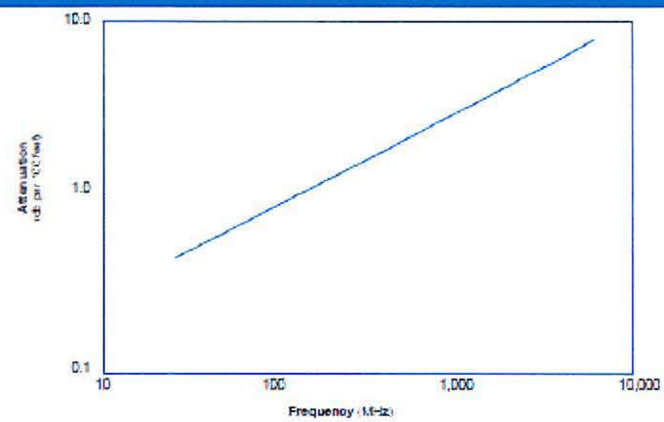
TIMES MICROWAVE SYSTEMS

A Smiths Group plc company

LMR-600-LLPL

Mechanical Specifications			
Performance Property	Units	US	(metric)
Bend Radius installation	in (mm)	1.5	(38.1)
Bend Radius repeated	in (mm)	6.0	(152.4)
Bending Moment	ft-lb (N-m)	2.75	(3.73)
Weight	lb/ft (kg/m)	0.24	(0.36)
Tensile Strength	lb (kg)	265	(120.3)
Flat Plate Crush	lb/in (kg/mm)	210	(3.75)

Attenuation vs. Frequency (typical)



Frequency (MHz)	30	50	150	220	450	900	1500	1800	2000	2500	3400	5800
Attenuation dB/100 ft	0.5	0.6	1.0	1.2	1.8	2.6	3.4	3.7	3.9	4.4	5.3	7.1
Attenuation dB/100 m	1.5	1.9	3.3	4.1	5.9	8.5	11.1	12.2	12.9	14.5	17.2	23.2
Avg. Power kW	6.97	5.39	3.08	2.53	1.75	1.22	0.93	0.84	0.79	0.70	0.59	0.44

Calculate Attenuation =

$(0.081390) \cdot \sqrt{FMHz} + (0.000160) \cdot FMHz$ (interactive calculator available at http://www.timesmicrowave/telecom)

Attenuation:

VSWR=1.0; Ambient = +25°C (77°F)

Power:

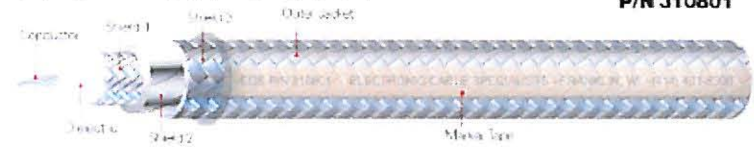
VSWR=1.0; Ambient = +40°C; Jacket = +75°C (167°F); Sea Level; dry air; atmospheric pressure; no solar loading

(800) TMS-COAX • www.timesmicrowave.com 79

"Providing complete avionics installation provisions and support for the Aerospace industry since 1984."

50 Ohm Coaxial Cable

P/N 310801



Conductor: 8 AWG stranded silver plated copper
Dielectric: High temperature flouropolymer
Shield 1: Flat silver plated copper braid
Shield 2: Aluminum foil
Shield 3: 36 AWG silver plated copper braid
Jacket: Clear high temperature flouropolymer (laser markable)

Physical Characteristics
Outer Diameter: 0.452 in. nominal
Bend Radius: 2.26 in. nominal
Weight: 19 lbs/100 ft nominal
Temperature Range: -55° to +200° C
Skydrol Resistant: Yes

Electrical Characteristics
Impedance: 50.0 Ohms nominal
Capacitance: 25.5 pF/ft nominal
DC Resistance: 0.67 Ohms/1000 ft nominal
Time Delay: 1.25 ns/ft nominal
Attenuation: (nominal) 1 GHz 3.50 dB/100 ft;
2 GHz 5.20 dB/100 ft;
3 GHz 6.75 dB/100 ft;
5 GHz 8.97 dB/100 ft

Environmental:
- ECS avionics cables are designed to meet, or exceed, burn requirements as set forth in Federal Aviation Regulations 14 CFR Part 25.869(a)(4) Amdt 25-113, Appendix F Part I(a)(3).
- They are manufactured with materials which, when subjected to flames or high temperatures, will not outgas deadly hydrogen chloride produced by conventional PVC cables.

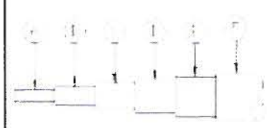
Connector Types for Cable 310801

Connector Type	Connector P/N	Connector Type	Connector P/N	Connector Type	Connector P/N
TNC 90°	CTR022	BNC 90°	CBR022	ARINC 404 Size 1	LM022
TNC 90° Extended	N/A	BNC 90° Extended	N/A	ARINC 600 Size 1	LO122
TNC 90° Long	N/A	BNC 90° Long	N/A	ARINC 600 Size 1RF	MO122
TNC Straight	CTS022	BNC Straight	CBS022	ARINC 600 Size 5	N/A
TNC Panel Mount	N/A	BNC Bulkhead	N/A	SMA 90°	N/A
TNC Bulkhead	BTS022	N 90°	CNR022	SMA Straight	N/A
C 90°	CCR022	N Straight	CNS022	HN 90°	CHR022
C Straight	CCS022	N Bulkhead	BNS022		

Cage Code: 66197 • **Issue Date:** 5/1/07

5300 W. Franklin Drive
Franklin, Wisconsin 53132 USA
414.421.5300 • 800.327.9473
sales@ecsdirect.com • www.ecsdirect.com

TENSOLITE CABLE DATA SHEET



CABLE CODE:	510
CATEGORY:	FLEXIBLE
DESCRIPTION:	SUPERFLEX
IMPEDANCE:	50 OHMS
MAX. OD:	0.217 INCHES
MAX. OPERATING FREQ.:	8 GHz
CUT OFF FREQ.:	32.3 GHz
CLAMP CABLE GROUP:	503
SOLDER CABLE GROUP:	N/A
CRIMP CABLE GROUP:	910
MIL SPEC:	N/A
FLORIDA PART X REF.:	N/A

ITEM	MATERIAL	SIZE
A. CENTER CONDUCTOR	STRANDED SILVER PLATED COPPER WIRE	0.036
B. DIELECTRIC:	POLYETHYLENE	0.116
C. INNER BRAID	SILVER PLATED COPPER WIRE	0.137
D. INTERLAYER	ALUMINUM / POLYESTER FOIL	0.143
E. OUTER BRAID	SILVER PLATED COPPER WIRE	0.165
F. JACKET	GRAY POLYURETHANE	0.212

MECHANICAL CHARACTERISTICS:

OUTER CONDUCTOR INTEGRITY:	60 POUNDS MINIMUM AXIAL PULL	
MINIMUM BEND RADIUS (ONE TIME)	1.27 INCHES	FIXED INSTALLATION
PREFERRED BEND RADIUS:	4.24 INCHES	
TEMPERATURE RANGE:	-40 / +85 DEGREES CELSIUS	
WEIGHT MAXIMUM:	0.043 POUNDS PER FOOT	

ELECTRICAL CHARACTERISTICS:

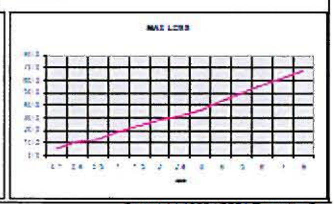
CENTER CONDUCTOR DC RESISTANCE	0.78 OHMS / 100 FEET NOMINAL	
OUTER CONDUCTOR DC RESISTANCE	2.48 OHMS / 100 FEET NOMINAL	
NOMINAL IMPEDANCE:	50 OHMS	
NOMINAL CAPACITANCE:	30.3 pf / FT	
NOMINAL INDUCTANCE:	0.076 uh / FT	
NOMINAL VELOCITY OF PROPAGATION	67.0 %	
NOMINAL DELAY:	1.52 nS / FT.	
MAXIMUM OPERATING VOLTAGE:	2645 VRMS	
MAXIMUM CW POWER RATING:	19 WATTS AT	8 GHz
MAXIMUM RETURN LOSS:	-23 dB AT	8 GHz
MAXIMUM INSERTION LOSS:	68.0 dB / 100 FT AT	8 GHz
NOMINAL INSERTION LOSS:	63.5 dB / 100 FT AT	8 GHz

To calculate maximum insertion loss at any frequency use the formula below:

15.752 times square root of freq. + 2.929 times freq. + 0 = dB/100'

RELATIVE SHIELDING: -100 dB TRIPLE SHIELDED

FEATURES: HIGHLY FLEXIBLE WITH RUGGED JACKET
ACCEPTS MOST DOUBLE RG142 CONNECTORS



Data subject to change